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ABSTRACT

Described are three experiments which probed children's sensitivity to structure or organization in visual patterns. Each experiment employed a different paradigm (complexity judgment, discrimination learning, recognition learning, and memory) in order to tap different aspects of children's use of structural information. Subjects were children in kindergarten through sixth grade as well as university students. Major findings were (1) indices of sensitivity to visual organization show dramatic changes with age; (2) children's sensitivity to visual structure depends upon the type of structure; and (3) whether or not sensitivity to structure is revealed depends upon the experimental task. (Author/MS)

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Sensitivity to Visual Structure

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Introduction

Today we will describe three experiments which probed children's sensitivity to structure or organization in visual patterns. Each experiment employed a different paradigm - complexity judgement, discrimination learning, recognition memory - in order to tap different aspects of children's use of structural information. Lest we keep you in suspense, we'll begin by outlining the major findings:

1) Indices of sensitivity to visual organization show dramatic changes with age
2) Children's sensitivity to visual structure depends upon the type of structure
3) That whether or not sensitivity to structure is revealed depends upon the experimental task.

That is, we have a case of diverging operations! But never fear, we will conclude with an effort to integrate these diverse results into some hypotheses about the development of visual encoding.

The 1st Experiment - Complexity Judgement

The first experiment involved judgements of the complexity of visual patterns. From previous research, we knew that two classes of variables influence adults' complexity judgements. Quantitative variation - as specified, for example, by amount of contour - directly influences complexity; the higher the pattern quantity, the more complex the pattern. The other factor is structural variation. Independent of pattern quantity, the presence of organization reduces pattern complexity. Therefore, both pattern quantity and type of structure were varied in this experiment.

Figure 1 shows the stimulus patterns we used. Amount of contour increases from left to right and each row represents a different type of organization. Six structure types were used - double symmetry vertical symmetry, horizontal symmetry diagonal symmetry checkerboard organization, and rotational organization. The design was completed by a set of unstructured patterns. Note that each structured pattern has a contour - matched instructional pattern.

A large, but still very incomplete pair comparison design was used in which the unstructured patterns served as a common yardstick of complexity against which to measure complexity of each type of structured pattern.

Children in grades K,2,4,6, and college students were asked to indicate the simpler pattern in each pair. From these data, we obtained complexity values for each pattern for each age group.

Although judged complexity increased uniformly with amount of contour at all ages, contour did not influence sensitivity to structure. That is, if a group's judgements were influenced by a particular structure type they were generally influenced by that type at all contour levels. Therefore, it was possible to obtain mean complexity values for each type of organization for each age group. These results are shown in Figure 2.

For each age group, the complexity of unstructured patterns was arbitarily set at zero. The complexity of each structure type is plotted relative to that standard. We observe that sensitivity to structure - which is measured by the distance below the unstructured patterns - changed with age and with the type of structure.

In particular, notice the difference between the K and G-2 groups. The K group was sensitive only to double symmetry (indicated by B) and vertical symmetry (indicated by V). Other types of structure did not differ in complexity from the unstructured patterns. Checkerboard patterns (indicated by K) are an example of this. In constrast, the G-2 group was sensitive to all six types of structure.

Secondly, notice that there was a dramatic change between the G-4 and G-6 groups. G-6 and college students judged all structured patterns, uniformly, to be much simpler than did younger subjects. The older subjects gave much greater weight to structure in the determination of their judgements. Finally, notice that the relative rank of types of structure changed with age. The K group was most sensitive to double symmetry (B) but did not judge checkerboards (K) to be simpler than unstructured patterns. College students, however, judged checkerboards to be the simplest of all patterns.

Thus two of the chief findings were already evident in this first experiment:

1) There were dramatic developmental changes in sensitivity to structure, and

2) sensitivity depended upon the type of pattern structure.

For the third finding, of course, we require another experimental task.

Discrimination

The second experiment investigated the use of two types of structural information - double symmetry and checkerboard organization in discrimination learning. Three discrimination problems were used.

In the first, all the patterns were unstructured and one of each contour-matched pair was randomly assigned as positive. In the second problem, the positive patterns were doubly symmetrical. In the third problem, the positive patterns were partial checkerboards. Thus, the first problem had to be solved by rote whereas the use of information specifying double symmetry or checkerboard organization would facilitate learning in the other two problems. Each of these discrimination problems was presented to groups of subjects in grades K, 2, 4, 6, and college. Figure 3 shows the results.

Number of trials to criterion is shown for each type of structure for the subjects reaching criterion in each age group. It is perfectly clear that the presence of structure in the positive pattern facilitates learning at all ages. There was also little evidence of a difference between the checkerboard and doubly symmetrical problems at any age.

Nevertheless, it is evident that these problems were not trivial for younger subjects even though they seem obvious to us -- and indeed were for many of the college student subjects.

Discrimination Transfer

These subjects who reached criterion on the discrimination problems were presented a transfer condition in order to determine the nature of the concept, if any, that had been acquired. A set of transfer patterns was shown to the subjects in a random order.

Half of these patterns are unstructured and half contain one of six types of visual structure. New exemplars of double symmetry and complete checkerboards are included. Subjects were asked to indicate which of these patterns should have a smile face (the positive indicator) on the back. Figure 4 shows the results of the transfer task.

Transfer results are shown for new exemplars of the training type of stimuli, for other structured patterns, and for unstrucutred patterns. The percentage of each type of pattern that was selected as positive is shown for each age group. The kindergarteners responded randomly in the transfer task. Children in grades 2, 4, and 6 distinguished among the classes of patterns, as did the college students. However, the college students responded in a qualitatively different way. Responding to the training type of stimulus approached 100% and responding to unstructured stimuli was more sharply suppressed. Responding to other types of structured stimuli was also very high. It appears that the concept acquired is stimulus structure in general, rather than the specific type of pattern structure. In so far as children show transfer, they also seem to respond to structure in

general.

This experiment gives us the third major finding -- that evidence of sensitivity to structure depends upon the experimental task. In the learning phase of this experiment, it appeared that double symmetry and checkerboard organization provided similar facilitation of learning at all ages -- in contrast to the results of the judgement task.

On the other hand, the transfer task provided another example of a developmental change in sensitivity to structure. While the G-6 subjects appeared identical to the college students in the judgement task, this transfer task differentiated these two groups of subjects.

Recognition

In our third experiment, we investigated the use of double symmetry and checkerboard organization in recognition memory. Children in grades 1, 3, and 5 and college students examined one of two sets of 16 patterns. These sets contained doubly symmetrical, checkerboard and unstructured patterns. After an interval in which the subjects performed a verbal task, they were shown the patterns from both sets and required to indicate which of the patterns they had seen.

The data have not yet been fully analyzed so only the raw scores will be presented. Figure 5 shows the percentage correct for each type of pattern for each age group; standard errors of the means are indicated by the bars.

First, note that at every age memory for doubly symmetrical patterns was superior to memory for checkerboards which, in turn, was superior to memory for unstructured patterns. That is, the presence of structure did facilitate memory, even for the youngest children in this experiment.

The delightful aspect of these results, however, is that they do not simply show generalized improvement with age. Only the recognition of symmetrical patterns improved between grades 1 and 3. Recognition of both symmetrical and checkerboard patterns, but not unstructured patterns, improved between grades 3 and 5. Finally, while recognition of symmetrical patterns did not improve from grade 5 to college, recognition of checkerboards continued to improve and recognition of unstructured patterns showed marked improvement.

Thus, in this experiment we again saw different types of structure behaving differently across age groups.

While there is some evidence of sensitivity to structure in all age groups, it appears that whatever aspect of sensitivity leads to improved recognition performance is first present for double symmetry and only then for checkerboards.

Conclusion

How do we make sense of this set of disparate results? The first step is to realize that neither "sensitivity to structure" nor "pattern encodability" should be viewed as a simple, unitary entity that will be transparently reflected in a wide range of tasks. The encoding, processing, and learning of visual patterns is a very complex sequence of events; different experimental tasks can be expected to tap different aspects of these processes. All three experimental tasks surely demanded perceptual encoding of the stimulus. However, the judgement task and the recognition memory task presumably differ from the discrimination learning task in requiring a relatively rapid, spontaneous encoding. And these tasks both place double symmetry as earlier in effectiveness than checkerboard organization. While the young child may not be totally without some kind of sensitivity to the organization of these patterns, he may have the parts of the code without the capacity to rapidly assemble them into a useful encoding of the pattern. In the task which seems to demand direct, perhaps conscious access to the structural features of patterns, the transfer task in the discrimination experiment, only the college students performed in a clear-cut, decisive manner. Other aspects of the results also suggest the theme of access to the code.

Many of you will have noticed that the age at which the dramatic changes in complexity judgement occurs coincides with the age of transition to the Piagetian stage of formal operations, often characterized in terms of acquisition of the capacity to reflect

upon one's own thought processes. Perhaps the change in complexity judgements is attributable to the subjects' awareness of the rule-bound character of the pattern structure. To meta-language and meta-memory, we may have to add meta-perception.

However, a major, though not necessarily mutually exclusive, alternative should be considered. There may be a qualitative change in the nature of the encodings that can be constructed -- to incorporate more complex, embedded structures. Such a change would have sufficiently wide-ranging effects to account for the general change in judgements. It would contribute to explaining the difficulty of checkerboard organization. It is consistent with the fact that only older subject's complexity judgments approximate objective information reduction. It is consi tent with the adults' superiority in the recognition of unstructured patterns since these patterns have more complex structural descriptions.

For this reason the next experiment in this series will be an explicit attempt to deduce the structure which these patterns have for subjects of different age.

Related Papers

Adult studies mentioned:

Chipman, S.F. Complexity and Structure in visual patterns. Journal of Experimental Psychology: General, in press.

Previous study.

Chipman, S.F. and Mendelson, M.J.
The development of sensitivity to visual structure.
Journal of Experimental Child, 1975, 20, 411-429.

Experiment 1:

Chipman, S.F. and Mendelson, M.J.
The influence of six types of visual structure on complexity judgements in children and adults.
Draft available.

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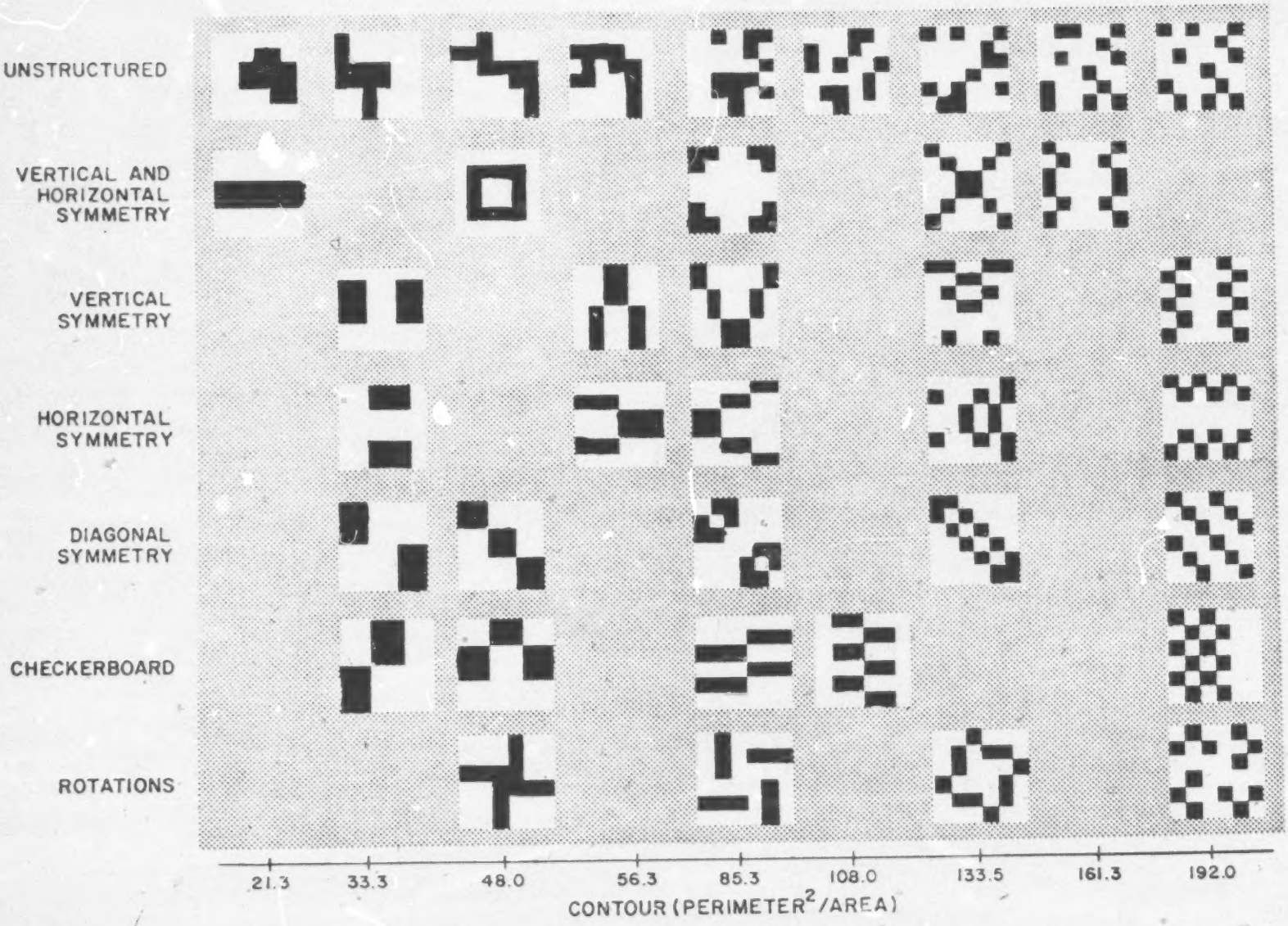


Fig. 1. Patterns used in pair comparison task.

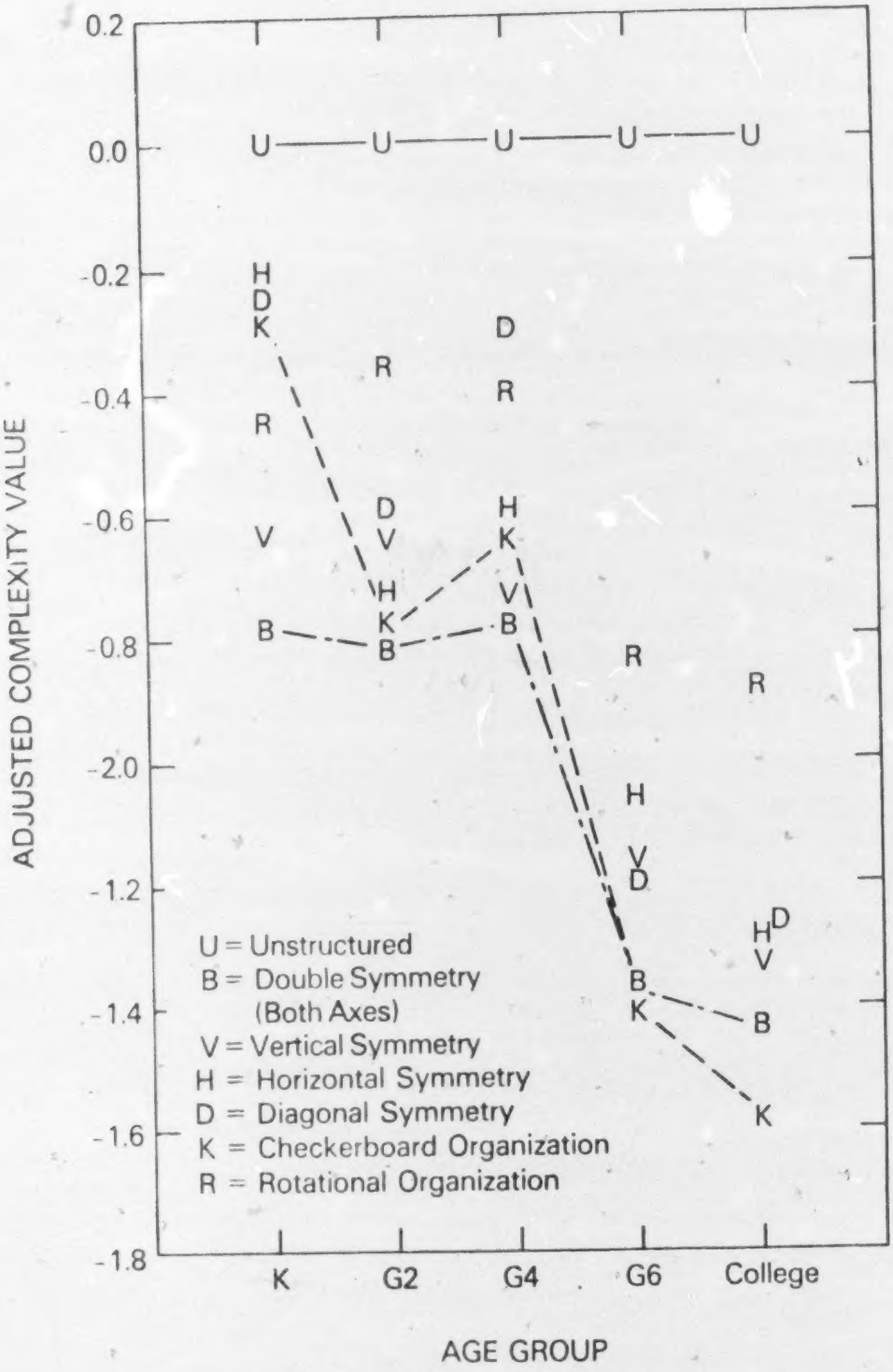
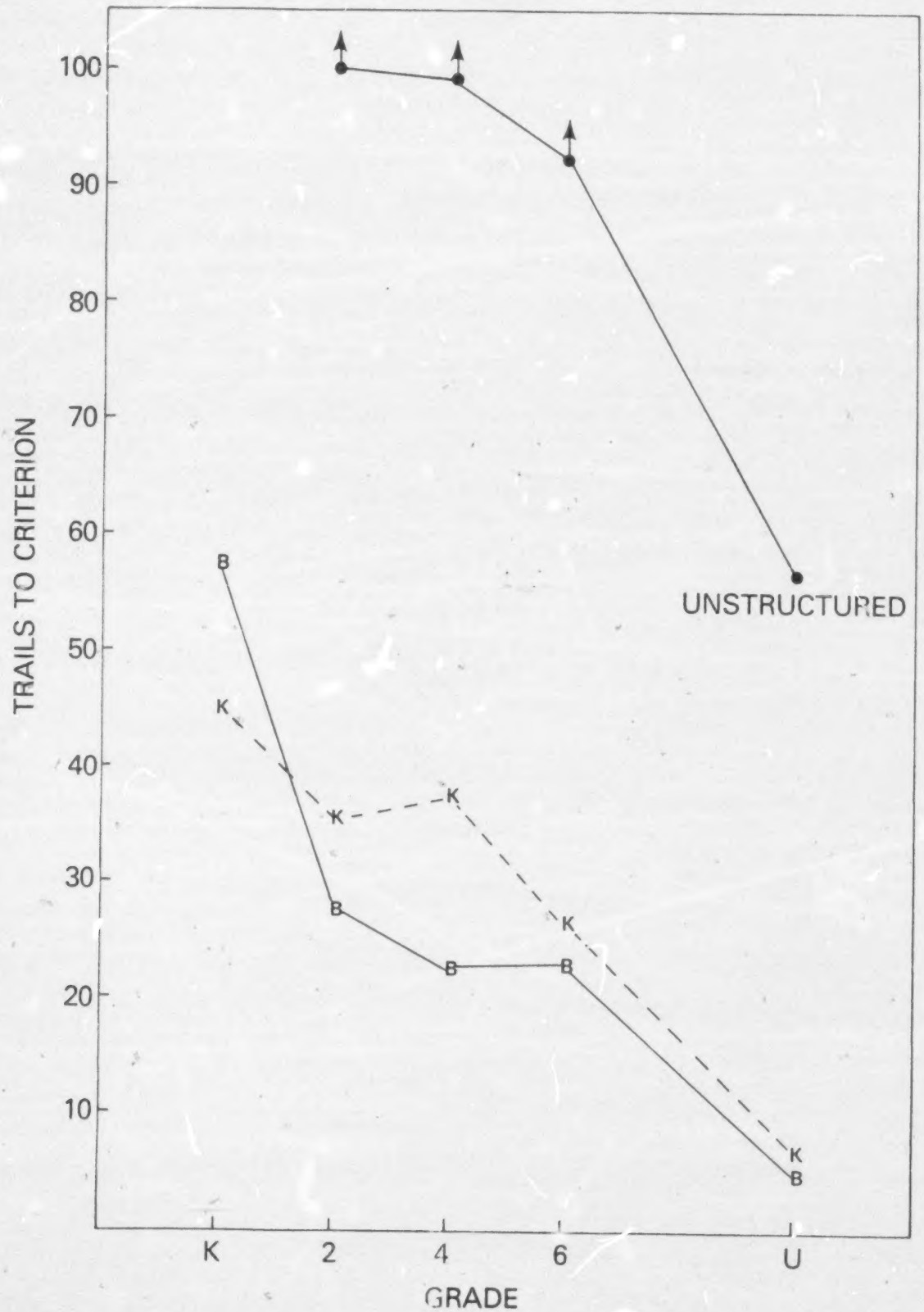
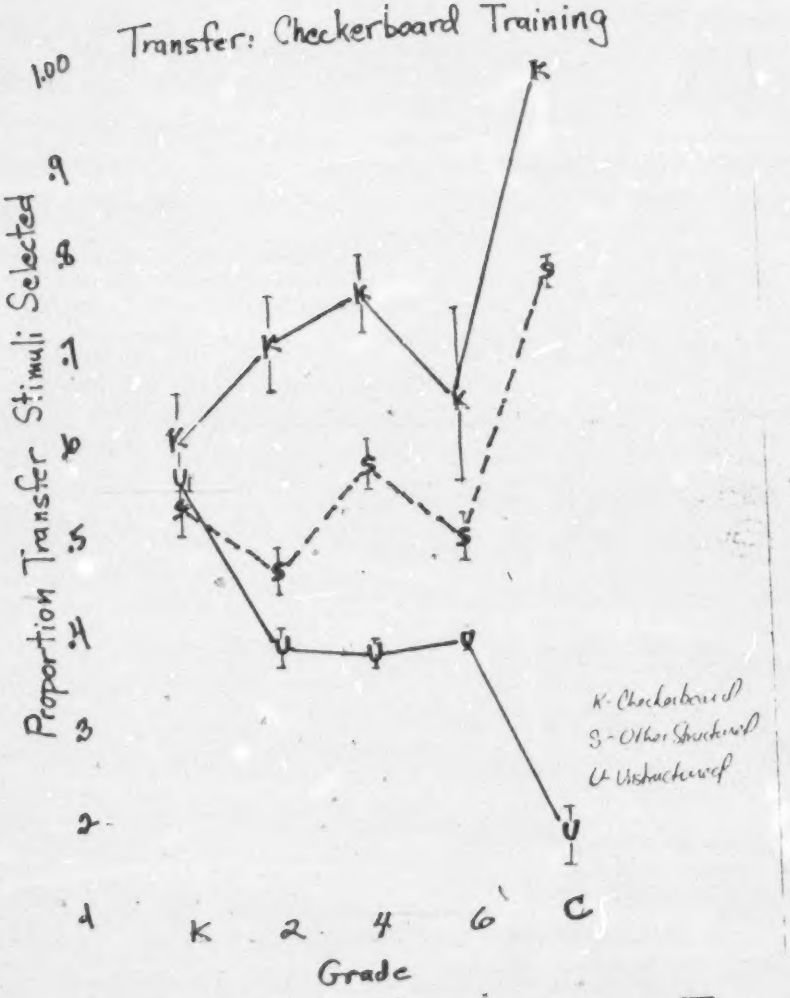


Fig. 2 Adjusted complexity for unstructured and six types of structured patterns for each age group.

Figure 3: Trials to criterion in the discrimination task.





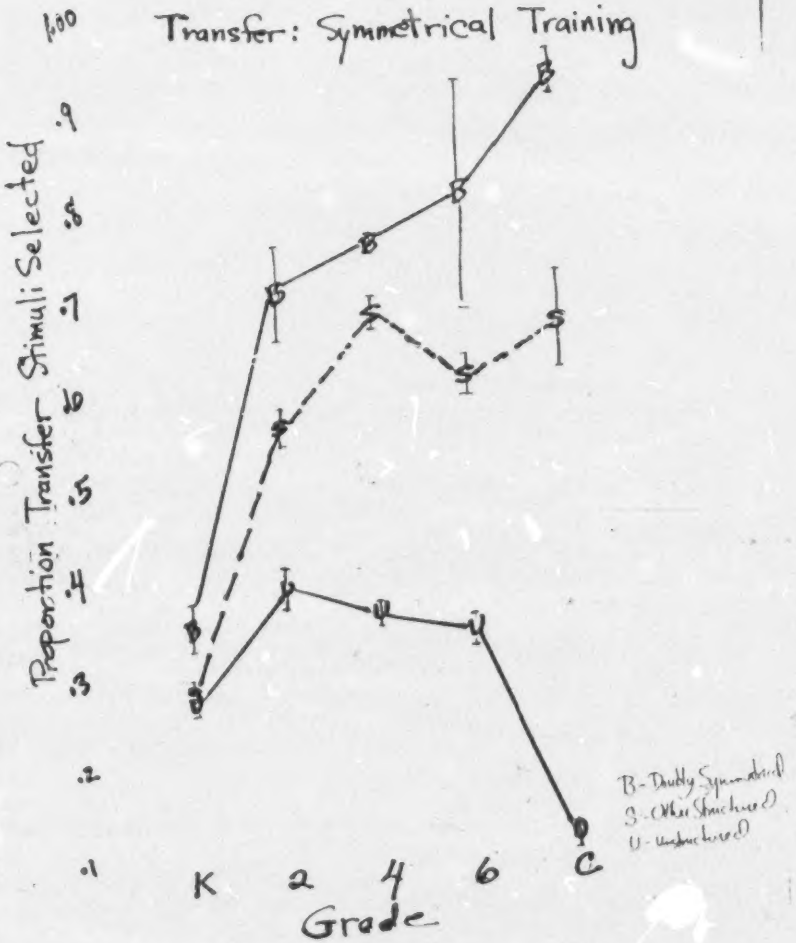


Figure 4
Transfer Results

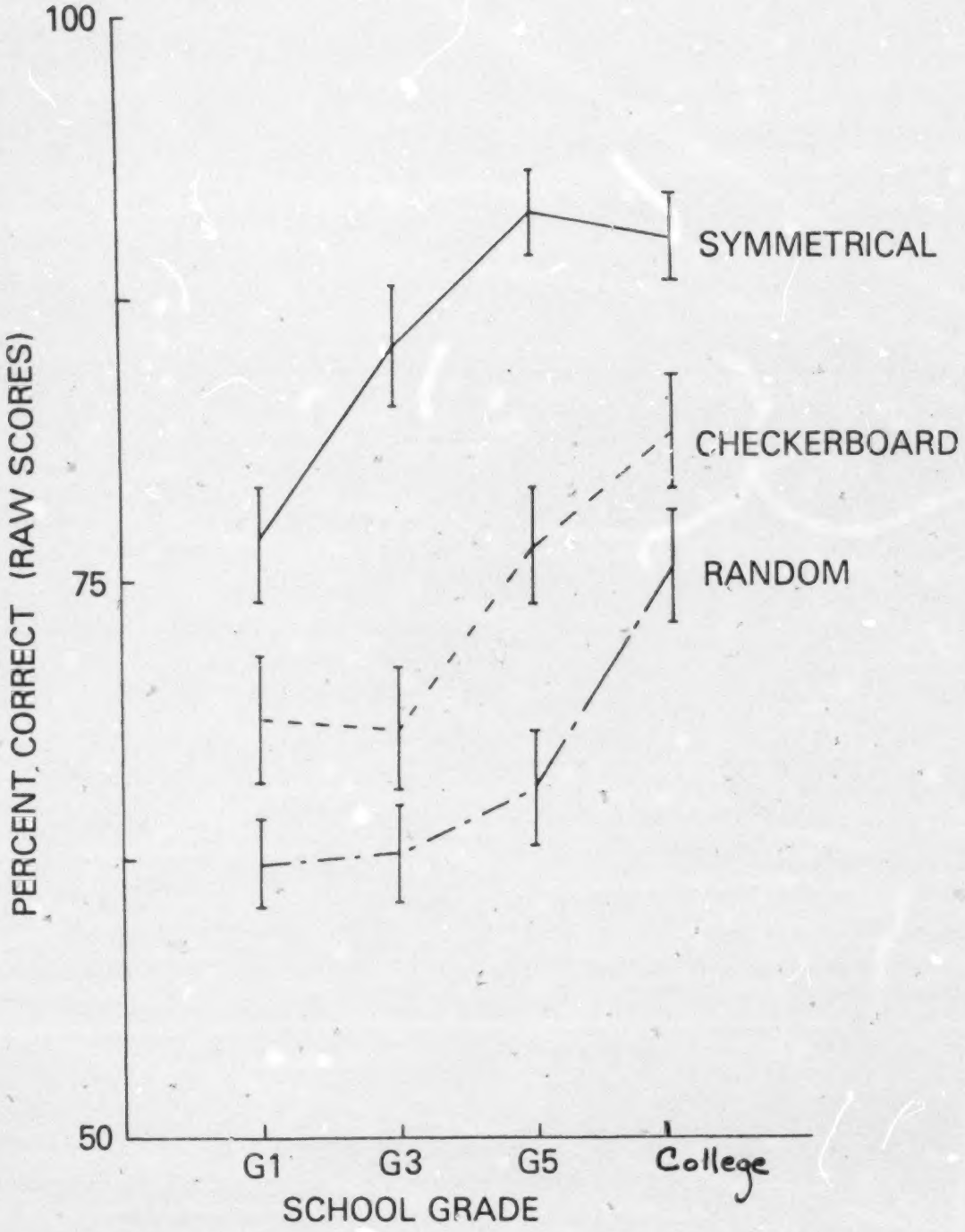


Figure 5: Percent correct in the recognition memory task.